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(54) Heatable Panels

(57) An electrically heatable light-transmitting glazing panel 1 comprises spaced electrically conductive bus strips 2, 3 interconnected by electrically conductive heating means deposited on a substrate of glazing material.

The panel includes a plurality of substantially parallel lines 6 of electrically conductive material deposited onto the substrate so that at least some of them are comprised in the heating means. The lines each have a width less than 0.5 mm and adjacent lines are spaced apart by less than 10 mm.

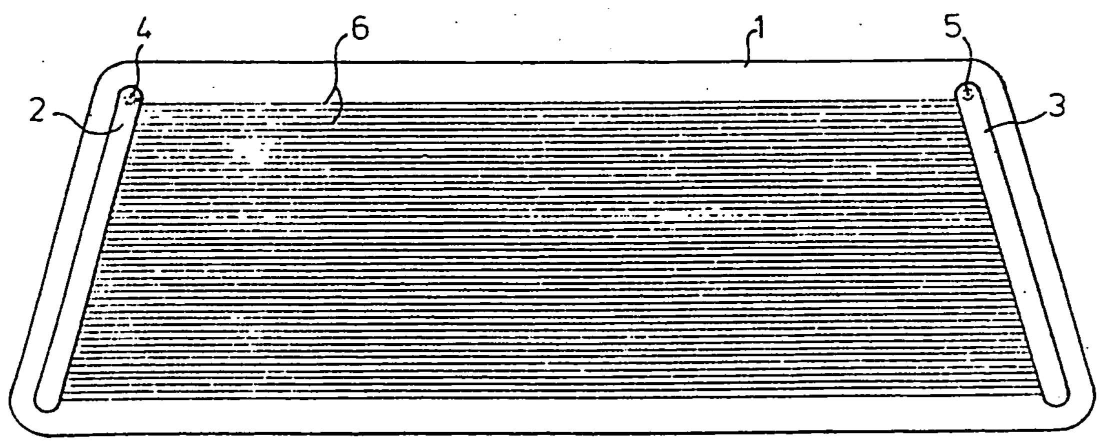

FIG.1

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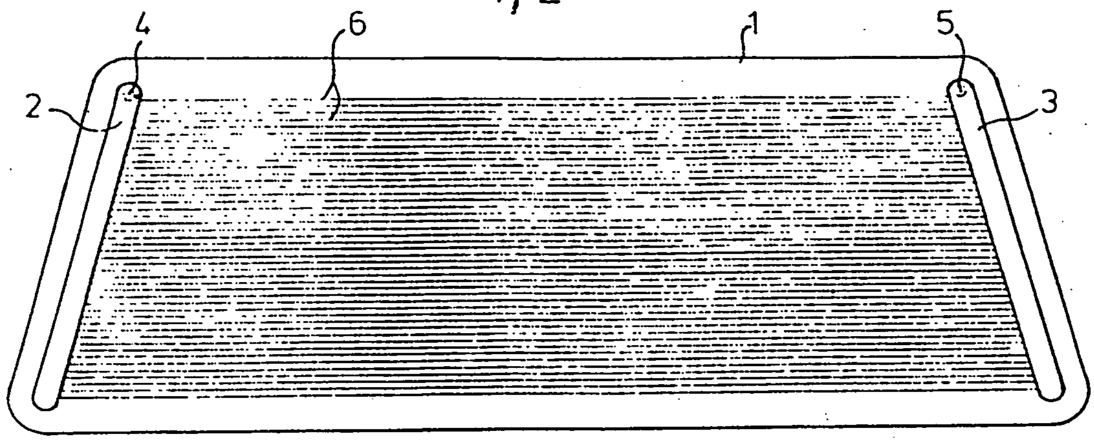


FIG.1

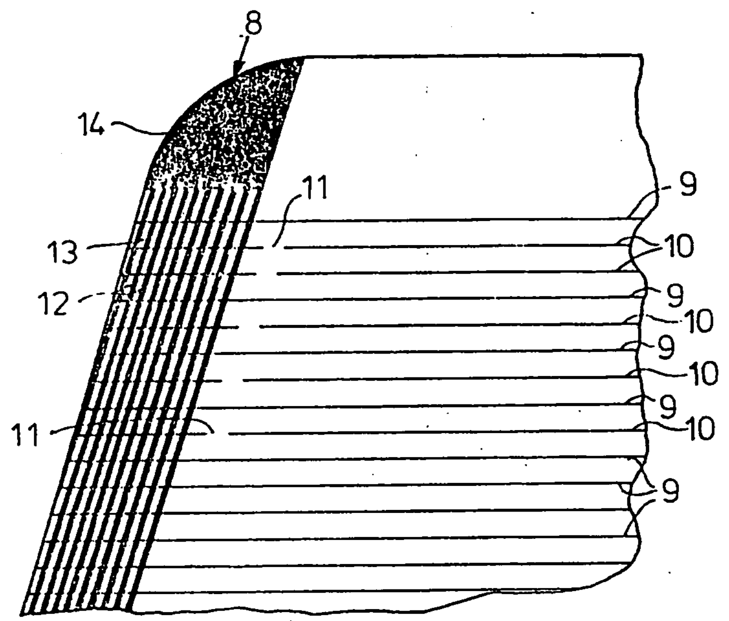
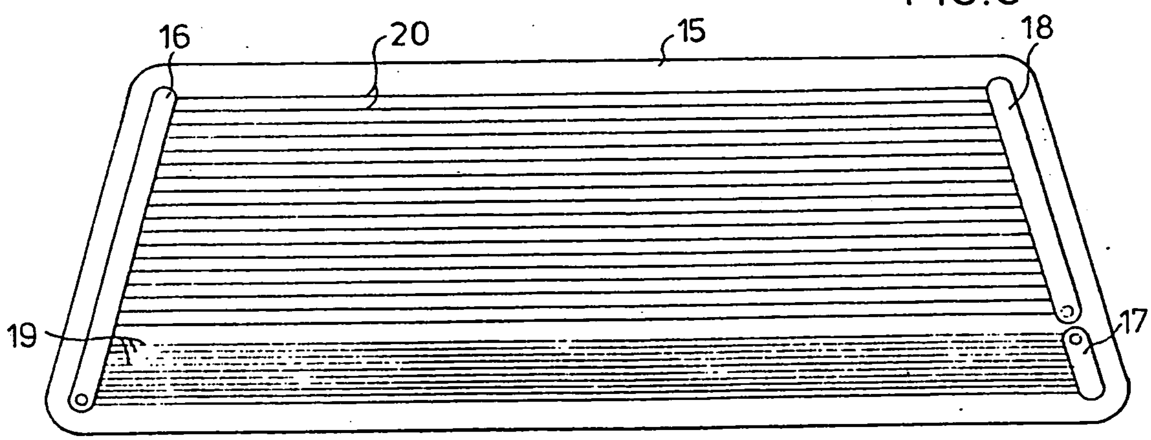


FIG.2

FIG.3



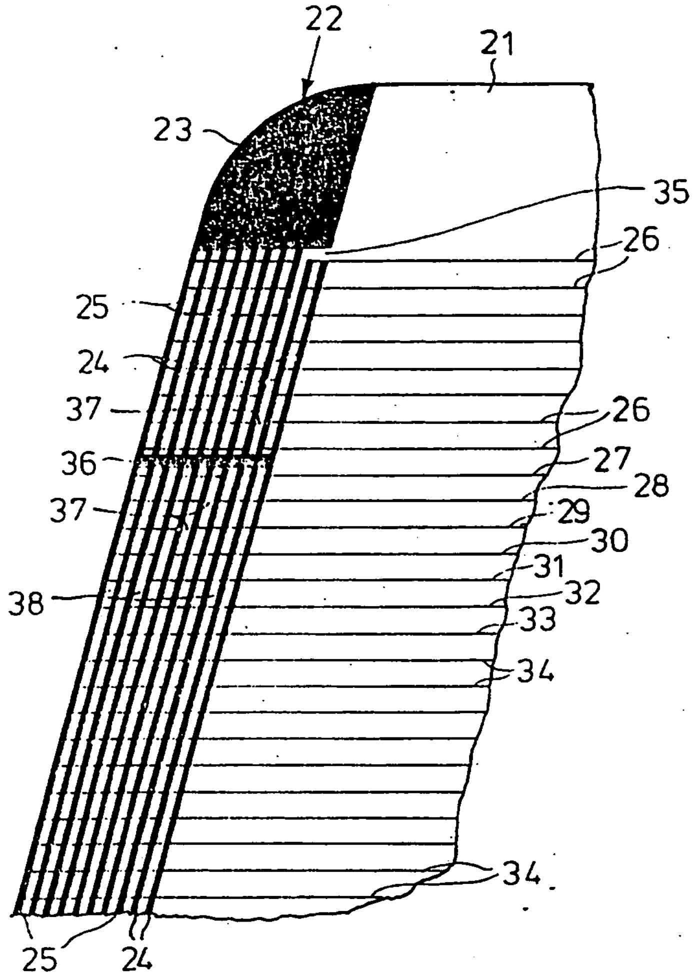


FIG. 4

SPECIFICATION
Heatable Panels

The present invention relates to an electrically heatable light transmitting panel comprising spaced electrically conductive bus strips interconnected by electrically conductive heating means deposited on a substrate of glazing material. The expression "glazing material" is used herein to denote light transmitting materials suitable for use in closing window openings. Among such materials are glass, vitrocrystalline materials and plastics materials.

Such heating panels are known to be particularly useful when embodied as vehicle windows, especially rear viewing windows of motor vehicles, and for other purposes.

It will be apparent from a walk through any car park that the majority of modern motor cars are provided with some form of rear window heater and that such heaters are overwhelmingly of a type comprising bus strips extending up the side margins of the window which are interconnected by a plurality of conductive heating elements extending generally horizontally across the window: each heating element is about 1 mm in width and the various elements are spaced apart by about 2.5 to 3.5 cm. The number of such elements will depend on the height of the area of the window which it is desired to heat. Often there are thirteen or fourteen such elements.

These heating elements are conventionally formed by serigraphic deposition of a conductive enamel which is heat-bonded to the window. The bus strips are usually formed in the same way and indeed at the same time. It is a usual requirement that the heat output from the window heater should be 140—160 watts, and this implies a total conductivity of the heater of about 1 reciprocal ohm in a 12 volt system.

Heatable panels of this known type suffer from a number of disadvantages. Visibility requirements dictate that the heating elements should be narrower, but conductivity requirements are such that even with a width of 1 mm, the heating elements must be made of a highly conductive silver-containing enamel. Of course silver is very expensive.

A further disadvantage lies in the line spacing of the heating elements. If one such element becomes broken, a strip across the window is left unheated and because of the width of this strip it may take some considerable time to de-mist or de-ice.

It is an object of the present invention to provide a new and alternative configuration of heater for an electrically heatable light transmitting panel in which one or more of the disadvantages referred to above is reduced. Particular advantages attendant on the adoption of various specific essential or optional features of the invention will be adverted to later in this specification.

According to the present invention, there is provided an electrically heatable light transmitting panel comprising spaced electrically conductive bus strips interconnected by electrically conductive heating means deposited on a substrate of glazing material, characterized in that said panel includes a plurality of substantially parallel lines of electrically conductive material deposited onto said substrate so that at least some of them are comprised in said heating means, said lines each having a width less than 0.5 mm and adjacent lines being spaced apart by less than 10 mm.

The present invention thus provides a new and surprising departure from what is, at least in the field of heatable vehicle windows, the almost, if not completely, universal modern practice. In effect the present invention proposes the use of linear heating elements which are more closely spaced, narrower and more numerous. The closer spacing of the heating elements affords the advantage that if one element should be broken, for example by over-enthusiastic cleaning of the panel, the width of the unheated strip across the window is much less than has hitherto been the case and consequently the delay in demisting or de-icing that strip is very much reduced. Also because the elements are more numerous, any such breakage will have a much lower effect on the overall heat output of the panel.

Because the deposited heating elements are narrower than has hitherto been proposed, they are not visually obtrusive. This is especially important when a panel according to the invention is embodied as a vehicle rear view window. The length of the optical path between a driver's eye and the rear window via a rear viewing mirror will of course depend on the type and size of the vehicle, but for almost all private motor cars the length of that path will be between 2 and 3 metres. A figure which is often quoted for the resolving power of the average human eye is 1 minutes of arc or about 3×10^{-4} radian, that is, 0.6 mm at 2 metres. Heating element lines having a said maximum width of 0.5 mm are of course below that value, and accordingly will not prove visually distracting. Vibration of a vehicle in which the heated panel is installed will also act in favour of reduced visual impact of the heating element lines.

In the most preferred embodiments of the invention, said conductive lines have a width below 0.3 mm and a spacing in the range of 2 mm to 6 mm.

In fact the width of the said conductive lines, together with their close spacing can impart to the panel (when viewed from distances greater than, say, 2 metres) a generally uniform veil-like appearance, and the light transmitting power of the panel will clearly depend at least in part on the relative areas occupied by the conductive lines and the spaces between them. In order to permit an adequate degree of visibility through the panel, it is preferred that, of that portion of the panel bounded by the outer boundaries of the outermost ones of said conductive lines and the inner boundaries of the bus strips, at most 20% is

covered by said conductive lines. This in fact represents the maximum preferred reduction in visible light transmissivity of the panel due to the conductive lines.

Even though the said lines are much narrower than those which have hitherto been used for the purpose in view, they are, for a given panel breadth much more numerous, and accordingly by operating in accordance with the present invention, it is possible to deposit a greater quantity of conductive material than has hitherto been done. This is an extremely important consequence of adopting the present invention, since it means that it is no longer necessary to use silver as the conductive component of the material and very much less expensive conductors can be used. Accordingly, it is preferred that said conductive material comprises an enamel which contains a base metal or a mixture of base metals as sole conductive component. The expression "base metal" is used herein in distinction from the expression "noble metal". Noble metals are silver, gold and platinum.

The optimum choice of such a base metal or base metal mixture will depend on a number of factors: ease of application, which is partly governed by melting or sintering temperatures; electrical conductivity; and resistance to aging. The or at least one said base metal is preferably selected from nickel, aluminium and copper.

The small effect on the overall heat output of a panel according to the invention when one of said conductive lines is broken has been adverted to. In fact this can be turned to advantage to meet two problems which are often encountered with heatable panels of the type with which this invention is concerned. One such problem arises in the manufacture of such panels, and it is this: it is very difficult in economically viable mass production to control accurately the amount of conductive material which is serigraphically deposited, so that the overall conductivity of successively deposited panel heaters may vary. Customers demand that panel heaters with which they are supplied should have a uniform conductivity as between one panel and the next, for example at a value of 1 reciprocal ohm. The conductivity of any given panel may be standardised by breaking as many heating lines as is necessary to reduce the conductivity of the heater to a desired value. This may be done each time the resistance value of the heater is below the desired value. Thus, the reproducibility may be improved by increasing the amount of material deposited so that with the range of conductivity variation found in practice, the lowest conductivity is at an acceptable level: the conductivity of panel heaters which have too high a conductivity can then be reduced by breaking one or more of said conductive lines. Accordingly, in some preferred embodiments of the invention, at least one of said conductive lines is discontinuous.

The second problem arises in use of the heatable panel. If such a panel is used in an inclined or vertical orientation with its said heater elements running generally horizontally, upper parts of the panel will be heated not only by Joule effect, but also by convection of air warmed by lower parts of the panel, and this leads to a non-uniform and therefore less economic heating of the panel. This problem is compounded since in the field of motor vehicle rear windows, the panels are often trapezoidal in shape with their shorter parallel side at the top. In order to achieve uniform, or more uniform, heating of the panel, the heater output in the upper parts of the panel must therefore be reduced, and this can readily be done by breaking one or more of said conductive lines.

Accordingly, in some embodiments of the invention in which said bus strips converge towards one edge of the panel so that the distance between them is reduced in that edge region, it is preferred that at least one said conductive line is discontinuous in such region.

The problem of accurate control of conductivity of successively produced panel heaters can be solved in another way, namely by controlling the amount of conductive material initially deposited so that the highest conductivity achieved in a normal production run is at or below the conductivity required and then increasing the conductivity by the amount necessary for any given panel by an electroplating process. Accordingly in some preferred embodiments of the invention, at least some of said conductive lines include a base metal electrolytically deposited onto said conductive material. Whether any given manufacturer chooses to control panel heater conductivity by applying an excess of initially deposited conductive material or by electroplating as aforesaid will of course depend on customer requirements, and the method chosen will usually be that which is more economical. This may vary from time to time, and indeed from factory to factory. Of course even when the heating panel has been provided with an electrolytically deposited base metal it is still possible to adjust the resistance of the panel to a desired value or to modify the heating pattern by providing interruptions in the conductive lines as above described.

When a panel heater is electroplated as aforesaid, it will be usual for the whole panel to be immersed in the electrolyte, so that the bus strips are also electroplated, and this makes it possible to obtain further advantages. It will be appreciated that the spaced bus strips of the panel should have as low a resistance as is consistent with a commercially viable product. This is especially so as regards those portions of a bus strip which lie within a few (say 5) centimetres of a current input terminal, since those portions are especially apt to become overheated. It will also be appreciated that for practical reasons, the whole panel is dipped in electrolyte so that the bus strips and conductive lines are electroplated at the same time. As has been explained, in the manufacture of heatable

vehicle windows it is generally desirable for the heater to have a resistance of about 1 ohm, and thus the panel must be withdrawn from the electrolyte when this resistance value has been achieved, no matter how much material has been deposited on the bus strips. A way has now been found of forming the bus strips which enables the electrolytic deposition of metal thereon to be increased in rate especially close to the current input terminals. Accordingly, it is preferred that each said bus strip comprises electrically conductive material deposited on the substrate over the area to be occupied by that bus strip in a pattern such that the conductive material extends continuously along the length of the area of the strip leaving bare interstices distributed along that area, and an electrolytically deposited base metal overcoating. By adopting this feature, bus strips can be formed which have a higher conductance close to their terminals thus providing favourable conductance characteristics for the bus strips in use, with the result that excessive heating of such a bus strip in its terminal region is reduced or avoided.

For reasons of economy, conductivity and resistance to aging, the most preferred electrolytically deposited metal is copper and/or nickel.

When use is made of a pattern-wise deposited bus strip as aforesaid, useful modification of the heat output distribution can be achieved by ensuring that at least some of said conductive lines of the heating means are directly connected to one or some only of a plurality of bus lines constituting such patterned deposit as is preferred in some embodiments of the invention. One way of achieving this is to ensure that one or some of said conductive lines and/or one or some of said bus lines exhibits at least one discontinuity allowing direct electrical connection between one or some of said conductive lines and one or some only of said bus lines. As an optional additional feature of such embodiments, the or at least one of said bus lines is discontinuous to one side of its point of connection to a said conductive line of the heating means and the or each discontinuous bus line is connected to at least one other bus line by a transverse bus line located on the opposite side of such discontinuity to a terminal point adapted to receive a current supply wire connection.

Preferred embodiments of the invention will now be described by way of example only with reference to the accompanying diagrammatic drawings in which:

Figure 1 is an elevation of a first embodiment of heater panel according to the invention;

Figure 2 is a detail view of a corner of a second embodiment of heater panel;

Figure 3 is an elevation of a third embodiment of heater panel, and

Figure 4 is a detail view of yet a further embodiment of the invention.

In Figure 1, a heatable light transmitting panel comprises a substrate 1 of glazing material, for example tempered glass. Bus strips 2, 3 formed using conductive enamel which is deposited on and heat bonded to the substrate 1 extend up opposite side margins of the substrate. Lead in terminals 4, 5 are provided at the upper ends of the bus strips 2, 3 for the supply of heating current. A plurality of fine, closely spaced heating elements 6 is deposited on the substrate using a conductive enamel to interconnect the bus strips 2, 3. In accordance with the invention, these heating elements 6 are substantially parallel, have each a width below 0.5 mm, and each is spaced from its neighbour or neighbours by less than 10 mm. In a particular example they are 0.1 mm wide, and spaced apart by 2 mm. In Figure 2, a substrate 7 of glazing material is provided with bus strips such as 8 leading along opposed side margins of the substrate. The bus strips 8 are formed by serigraphic deposition of conductive enamel, as are a plurality of grid lines 9 and 10 which extend across the panel between the bus strips. The grid lines 9 form heating elements of the panel which is trapezoidal in shape and is intended to be installed with the shorter of its parallel sides uppermost. Because of this, the heating elements 9 in the upper part of the panel have a shorter length and thus a greater conductance than those in the lower part of the panel, so that unless some steps were taken, the heat output from the upper part of the panel would be greater than that from the lower part of the panel. This would compound the inequality of heat distribution up the panel due to convection effects which has already been referred to. In order to compensate for this, and provided a more uniform heat distribution up the panel, some of the grid lines 10 which are deposited at the same time as and are otherwise similar to the grid lines 9, are provided with breaks 11. This reduces the mean conductance of the grid lines in the upper part of the panel so reducing the heat output there and thus gives a more uniform temperature distribution up the panel. It will be appreciated that the number of grid lines 10 provided with breaks 11 may be varied as between successively produced panels, for example in order to compensate for variations in the amount of enamel deposited and thereby to impart a same desired total panel conductance to each successively produced panel. A panel of this sort has a substantially uniform appearance over its heatable area.

The bus strip 8 illustrated is formed by a plurality of conductive lines 12 spaced apart by interstices 13 and joined together at their upper ends by a solid terminal portion 14 for the attachment of a current supply wire. After the bus strips 8 and grid lines 9, 10 have been deposited on and bonded to the substrate 7, the panel is immersed in an electrolyte (for example copper sulphate solution) for the electro-deposition of a base metal onto the conductive enamel. It has been found that the rate of such electro-deposition on a patterned bus strip 8 of the type illustrated is greater close to the terminal 14 than

it is for a plain, uniformly deposited bus strip. Because of this, it is possible, for the same electrodeposition time, to make a bus strip which has a greater conductance close to its terminal.

It will be noted from the drawing that the conductive lines 12 of the bus strip 8 are inclined to the side edge of the substrate 7 so that the bus strip 8 will progressively decrease in width away from the terminal end 14. This provides a saving in the quantity of enamel used without adversely affecting current distribution to the heating elements 9.

Figure 3 illustrates a further embodiment of the invention in which a panel comprises a trapezoidal substrate 15 having a bus strip 16 leading up one side margin while the opposite side margin is provided with two bus strips 17, 18 arranged in tandem.

The lower bus strip 17 is connected to the bus strip 16 by a plurality of heating element lines 19 formed, like the three bus strips from conductive enamel. The heating element lines 19 have each a width of below 0.3 mm, and each is spaced from its neighbour or neighbours by between 2 mm and 6 mm.

The upper bus strip 18 is connected to the bus strip 19 by another heater which may be of any form, but is here shown as comprising a plurality of heating element lines 20.

The arrangement illustrated in Figure 3 permits variation in the heat output distribution of the panel. For example in a case where the panel is to form a vehicle rear window which is to be provided with a rear window wiper whose blade has a rest position lying across the bottom of the window, the heating elements 19 may be arranged to have a high heat output to facilitate rapid de-icing of the wiper blade rest position.

Separation of the bus strips 17, 18 permits selective energisation of one or other or both groups of heating elements 19 and 20.

In Figure 4, a panel comprises a substrate 21 of glazing material on a margin of which is deposited a bus strip 22. The bus strip 22 comprises a terminal portion 23 adapted for connection of a current supply wire, and bus lines 24, 25 extending along the panel margin. Linear heating elements 26 to 34 are deposited on the substrate 21.

To one side of the points of connection of the mesh lines 26 to the bus lines 24, between the heating means and the bus terminal portion 23, those bus lines 24 are interrupted by a discontinuity 35. On the opposite side of the discontinuity 35 to the bus terminal portion 23, the interrupted bus lines 24 are connected to the other bus lines 25 by one or more transverse bus lines 36. The heating element lines 26 are also interrupted by discontinuities (indicated at 37) extending across an interstice 38 between bus lines 24 and 25. Those heating element lines 26 are thus directly connected to only two of the bus lines indicated at 24. The result of this arrangement is that heating current to the linear heating elements 26 can only flow through the uninterrupted bus lines 25, the transverse bus line 36 and then the interrupted bus lines 24. This has the effect of reducing the heat output from those linear heating elements 26. Heating element lines 27 to 33 also exhibit discontinuities 37 extending across bus strip interstices 38. Heating element line 27 is thereby directly connected only to the bus lines 24 and one bus line 25, and the heating element lines 28 to 33 are successively connected to one additional bus line 25. The heat output of the linear heating elements 27 to 33 is thus also reduced, because they can only draw heating current from the bus lines 24 and some of the bus lines 25. It will be appreciated that portions of the heating element lines 26 to 33 to the left of their discontinuities 37 could if desired be omitted, but the discontinuities are preferably formed by removing previously deposited conductive material since this provides increased versatility in series production. Heating element lines 34 are connected to all the bus lines.

As examples of suitable materials which may be used to form the linear heating elements of a panel according to the invention are those available from Engelhard of Valley Road, Cinderford, Gloucestershire under their references T-2497 (aluminium containing enamel) and T-3731 (nickel containing enamel). These enamels are approximately 40% of the cost of a silver containing enamel.

Claims

1. An electrically heatable light transmitting panel comprising spaced electrically conductive bus strips interconnected by electrically conductive heating means deposited on a substrate or glazing material, characterised in that said panel includes a plurality of substantially parallel lines (6) of electrically conductive material deposited onto said substrate so that at least some of them are comprised in said heating means, said lines each having a width less than 0.5 mm and adjacent lines being spaced apart by less than 10 mm.

2. A panel according to Claim 1, characterised in that said conductive lines (6) have a width below 0.3 mm and a spacing in the range of 2 mm to 6 mm.

3. A panel according to Claim 1 or 2, characterised in that, of that portion of the panel (1) bounded by the outer boundaries of the outermost ones of said conductive lines (6) and the inner boundaries of the bus strips (2, 3), at most 20% is covered by said conductive lines.

4. A panel according to any preceding claim, characterised in that said conductive material comprises an enamel which contains a base metal or a mixture of base metals as sole conductive component.

5. A panel according to Claim 4, characterised in that the or at least one base metal is selected from nickel, aluminium and copper.

6. A panel according to any preceding claim, characterised in that at least one (10) of said conductive lines (9, 10) is discontinuous.

7. A panel according to Claim 6, characterised in that said bus strips (8) converge towards one edge of the panel so that the distance between them is reduced in that edge region and in that at least one said conductive line (10) is discontinuous (11) in such region.

8. A panel according to any preceding claim, characterised in that said conductive lines (6) include base metal electrolytically deposited onto said conductive material.

9. A panel according to any preceding claim, characterised in that each said bus strip (8 or 22) comprises electrically conductive material deposited on the substrate over the area to be occupied by that bus strip in a pattern (12 or 24, 25) such that the conductive material extends continuously along the length of the area of the strip leaving bare interstices (13 or 38) distributed along that area, and an electrolytically deposited base metal overcoating.

10. A panel according to Claim 8 or 9, characterised in that said electrolytically deposited base metal is copper and/or nickel.

11. A panel according to Claim 9, characterised in that at least some of the conductive lines (26 to 33) of the heating means are directly connected to one or some only (24, 25) of a plurality of bus lines (24, 25) forming such patterned deposit.

12. A panel according to Claim 11, characterised in that one or some of said conductive lines (26 to 33) and/or one or some of said bus lines (24, 25) exhibits at least one discontinuity (35 or 37) allowing direct electrical connection between one or some of said conductive lines (26 to 33) and one or some only of said bus lines (24, 25).

13. A panel according to Claim 12, characterised in that the or at least one of such bus lines (24) is discontinuous (35) to one side of its point of connection to a said conductive line (26) of the heating means and in that the or each discontinuous bus line (24) is connected to at least one other bus line (25) by a transverse bus line (36) located on the opposite side of such discontinuity (35) to a terminal point (23) adapted to receive a current supply wire connection.

14. A panel substantially as herein described with reference to any of the accompanying drawings.

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